

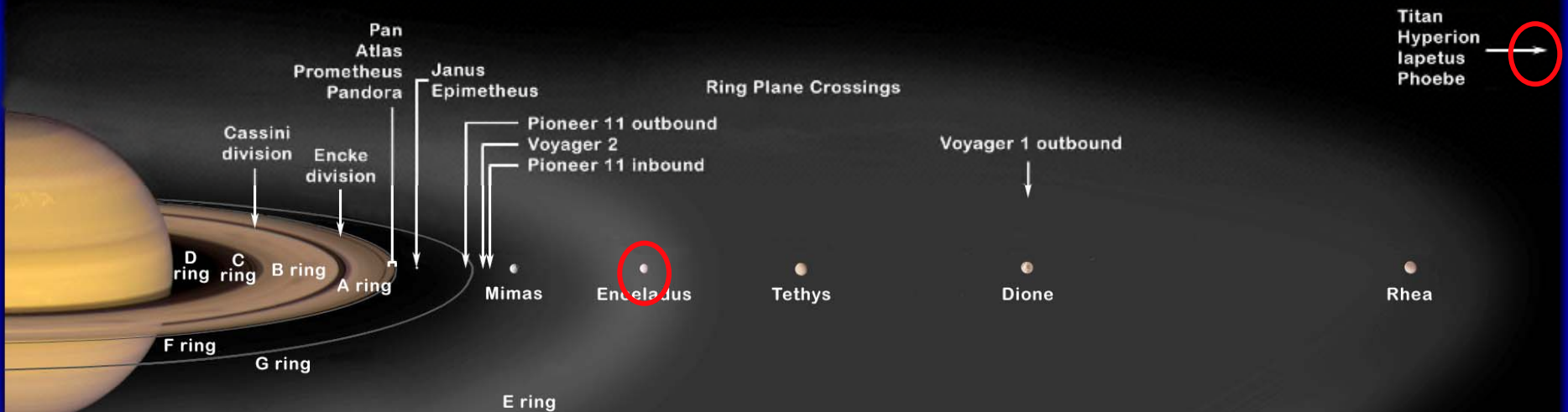
Hydrocarbons on the Icy Satellites of Saturn

Dale P. Cruikshank
NASA Ames

Paris Workshop
May, 2010



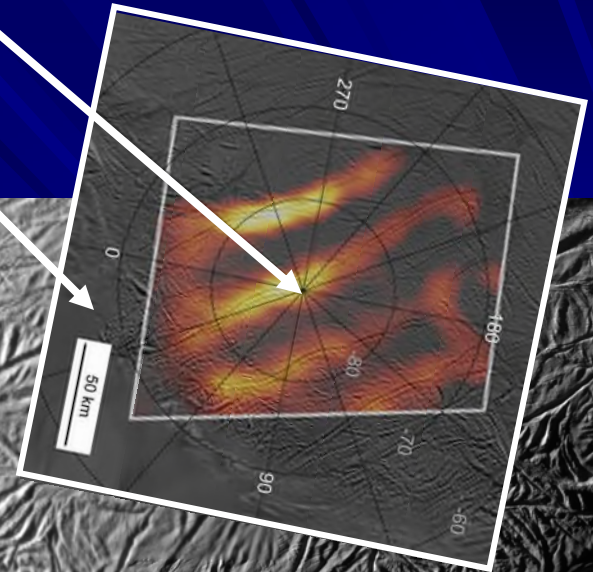
Saturn's Satellites and Ring Structure



Enceladus

$T = 180 \text{ K}$

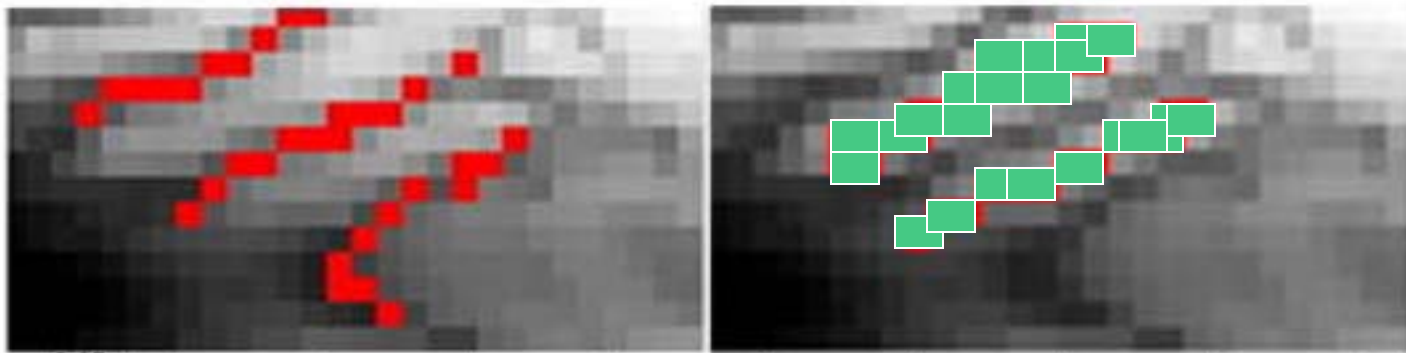
$T < 72 \text{ K}$



“Tiger Stripes”

$\sim 80 \text{ km}$

Diameter 500 km
Cassini ISS and CIRS images

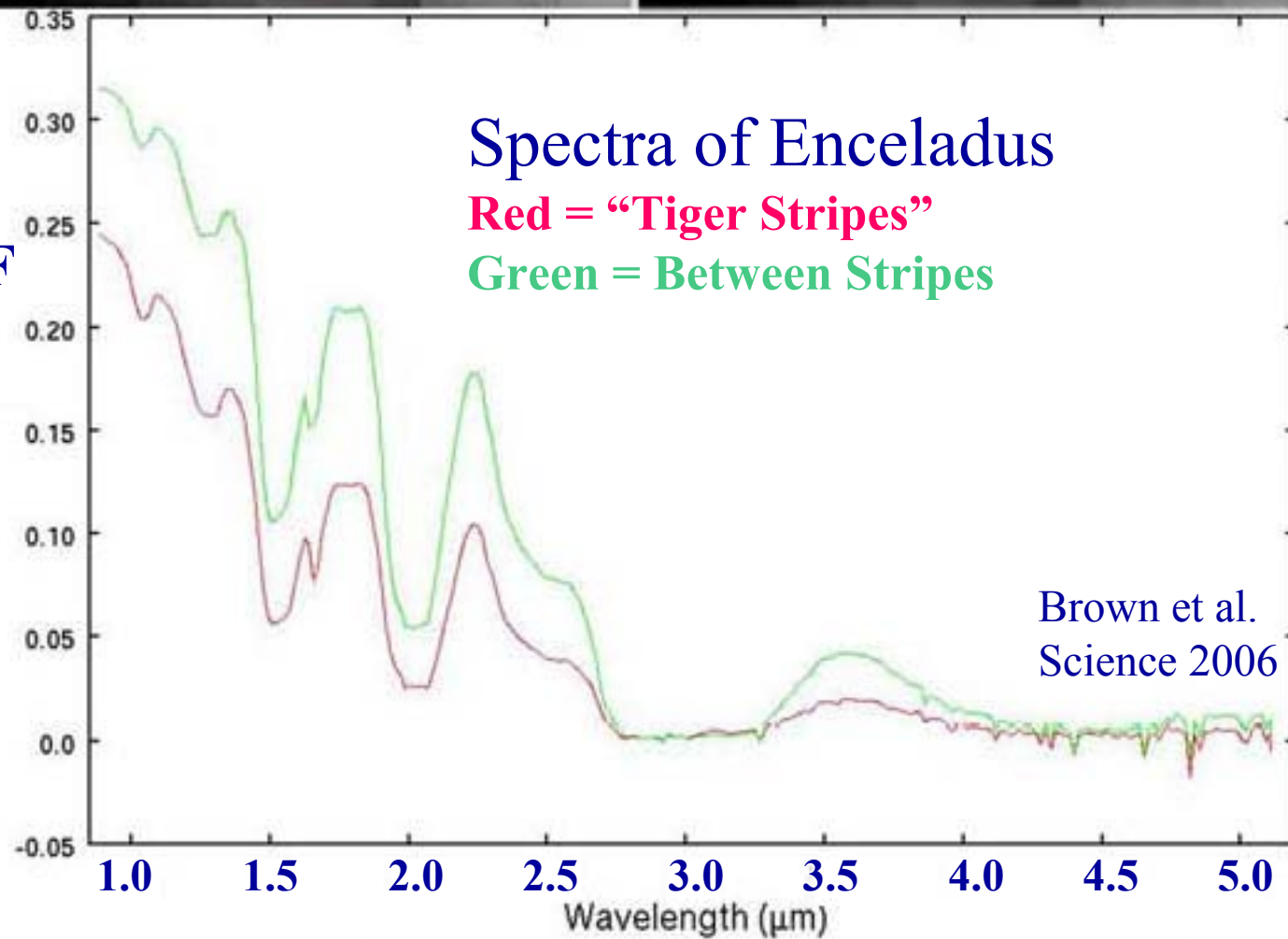


I/F

Spectra of Enceladus

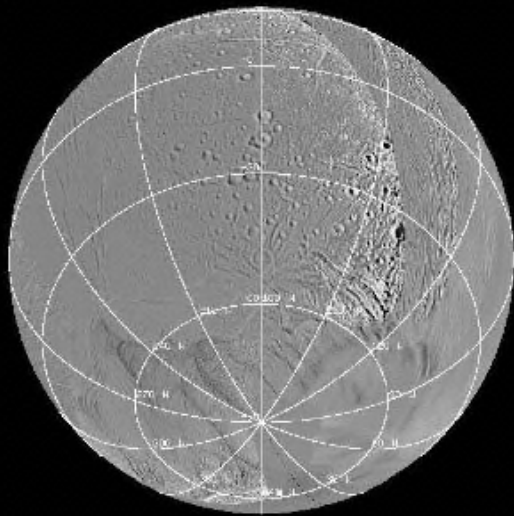
Red = "Tiger Stripes"

Green = Between Stripes

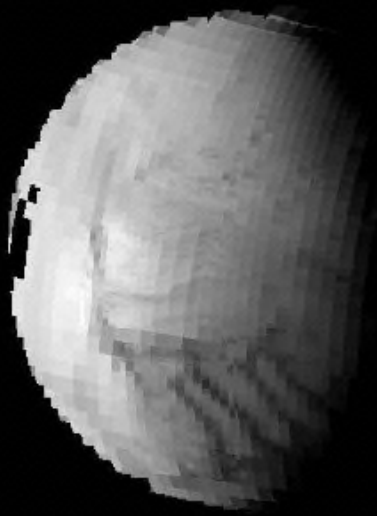


Brown et al.
Science 2006

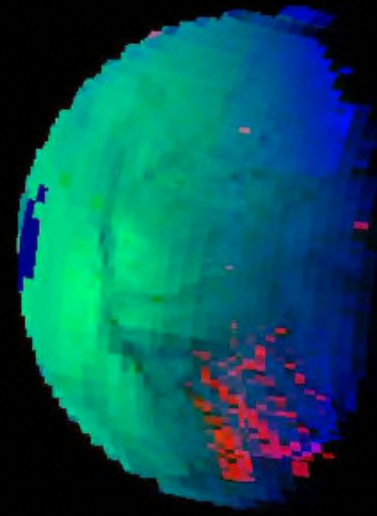
Spectral Maps of Enceladus



ISS Reference



2.2-micron Reflectance

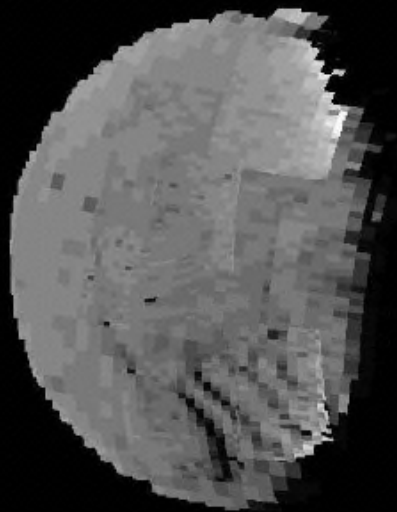


Color composite:

Red = 3.44-micron
Organics

Green = 2.2-micron
Reflectance

Blue = Ice Strength
at 3-microns



3-micron Ice
Absorption Strength



3.44-micron Organic
Absorption Strength

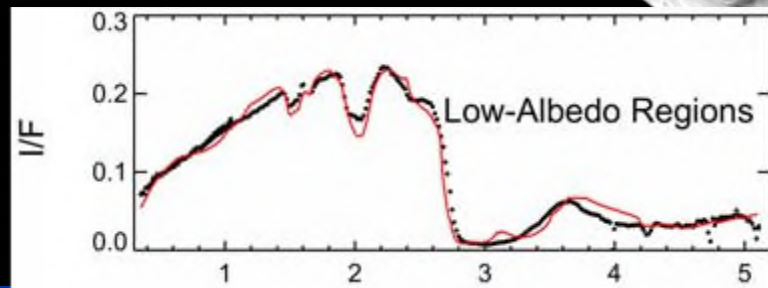
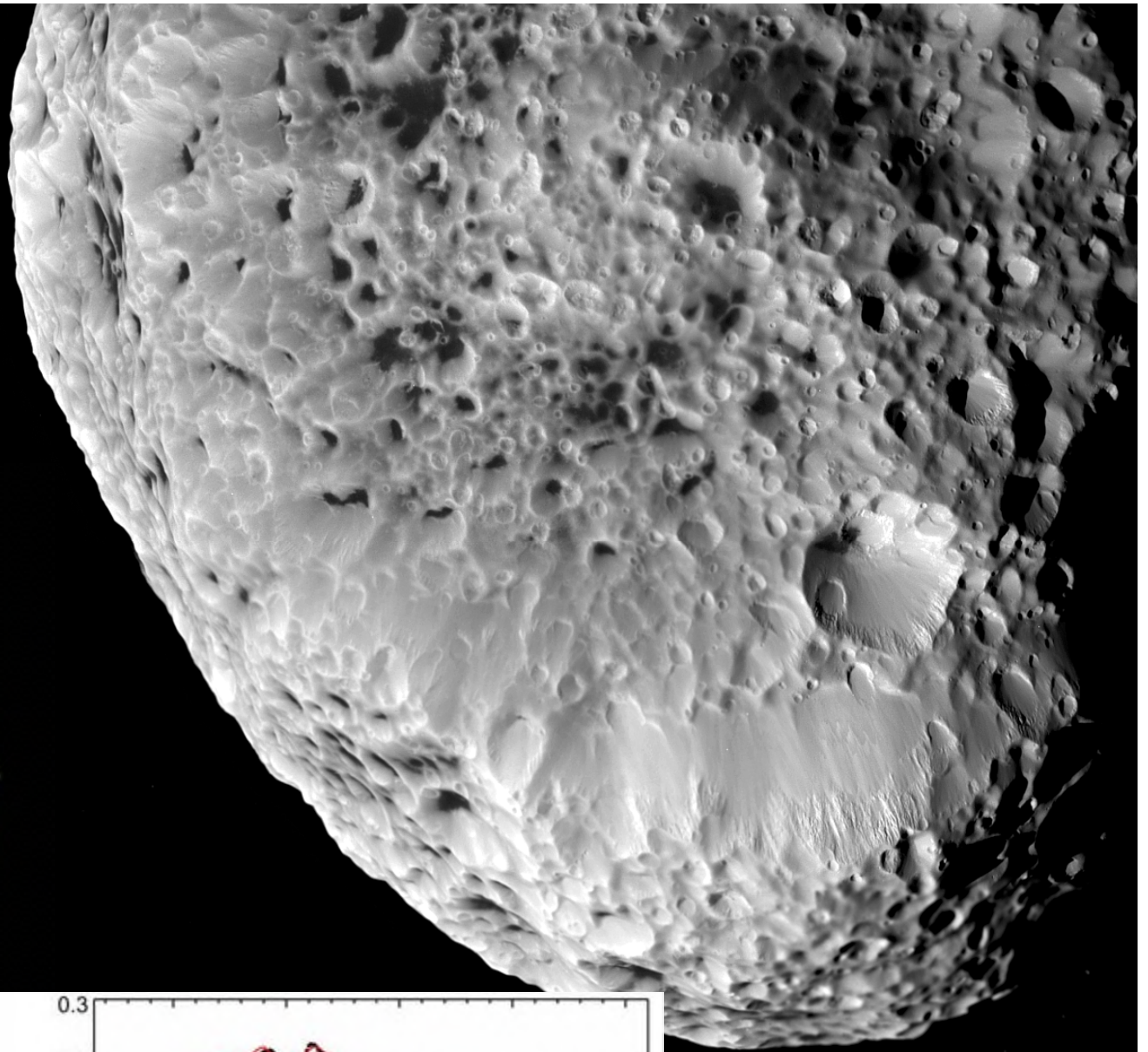
Cassini
Visual and Infrared
Mapping Spectrometer

Brown et al.
Science 2006

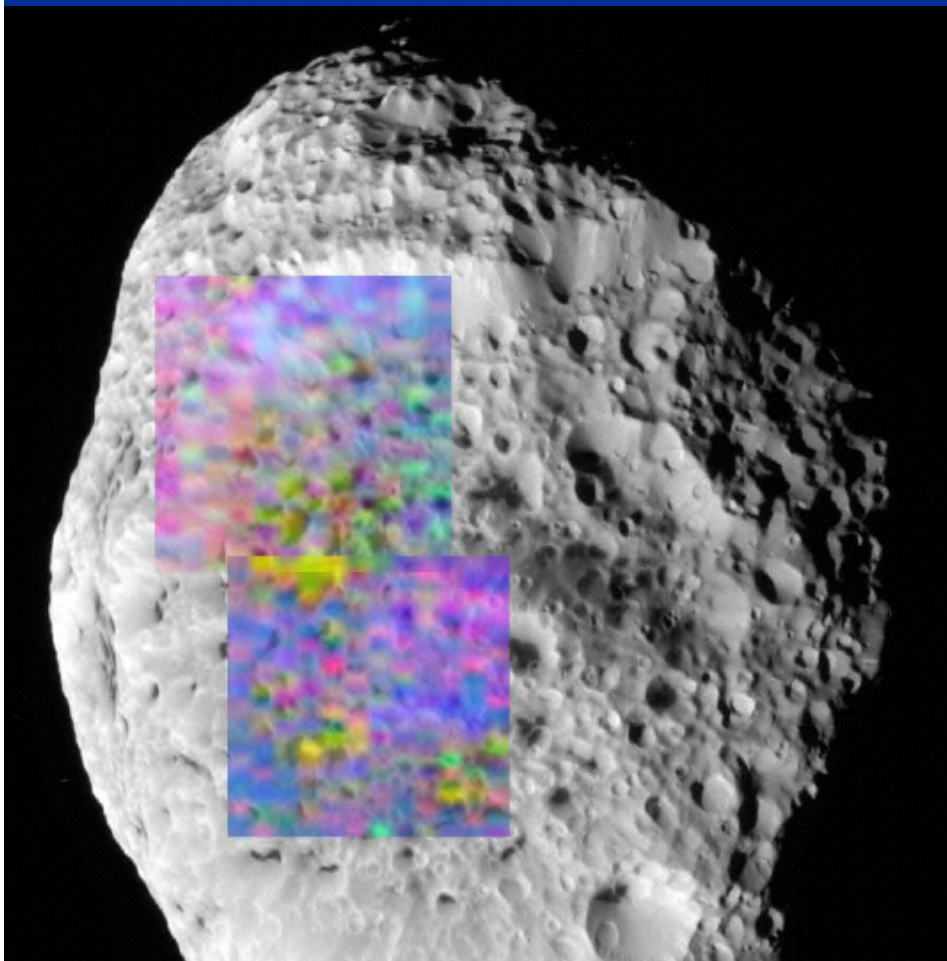
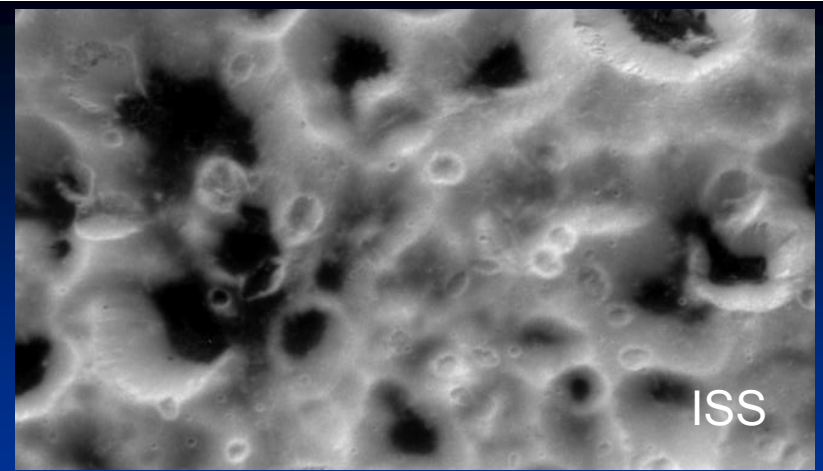
Dark Material on Hyperion

360×280×225 km

Density 0.6 g/cm³



Spectrum model with
H₂O ice and tholin



Hyperion Composition Map

Color code:

Blue = H₂O band depth

Red = CO₂ band depth

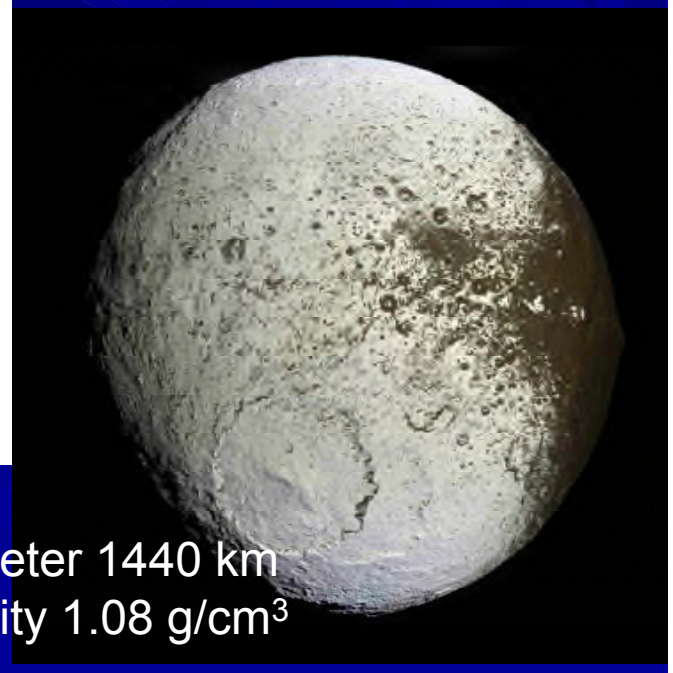
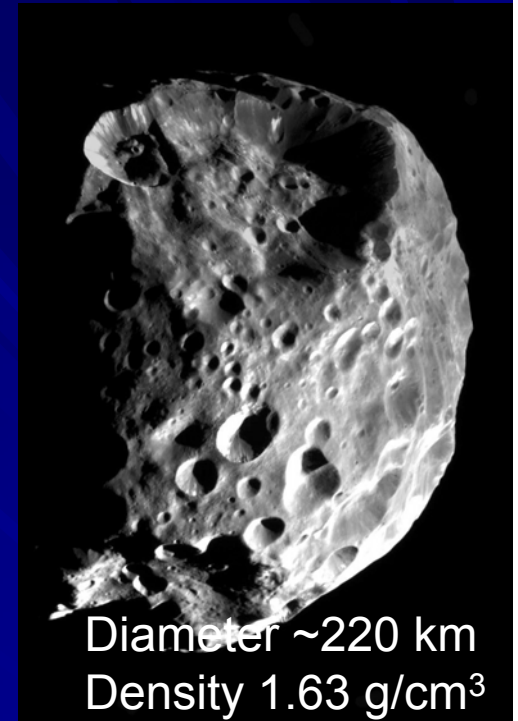
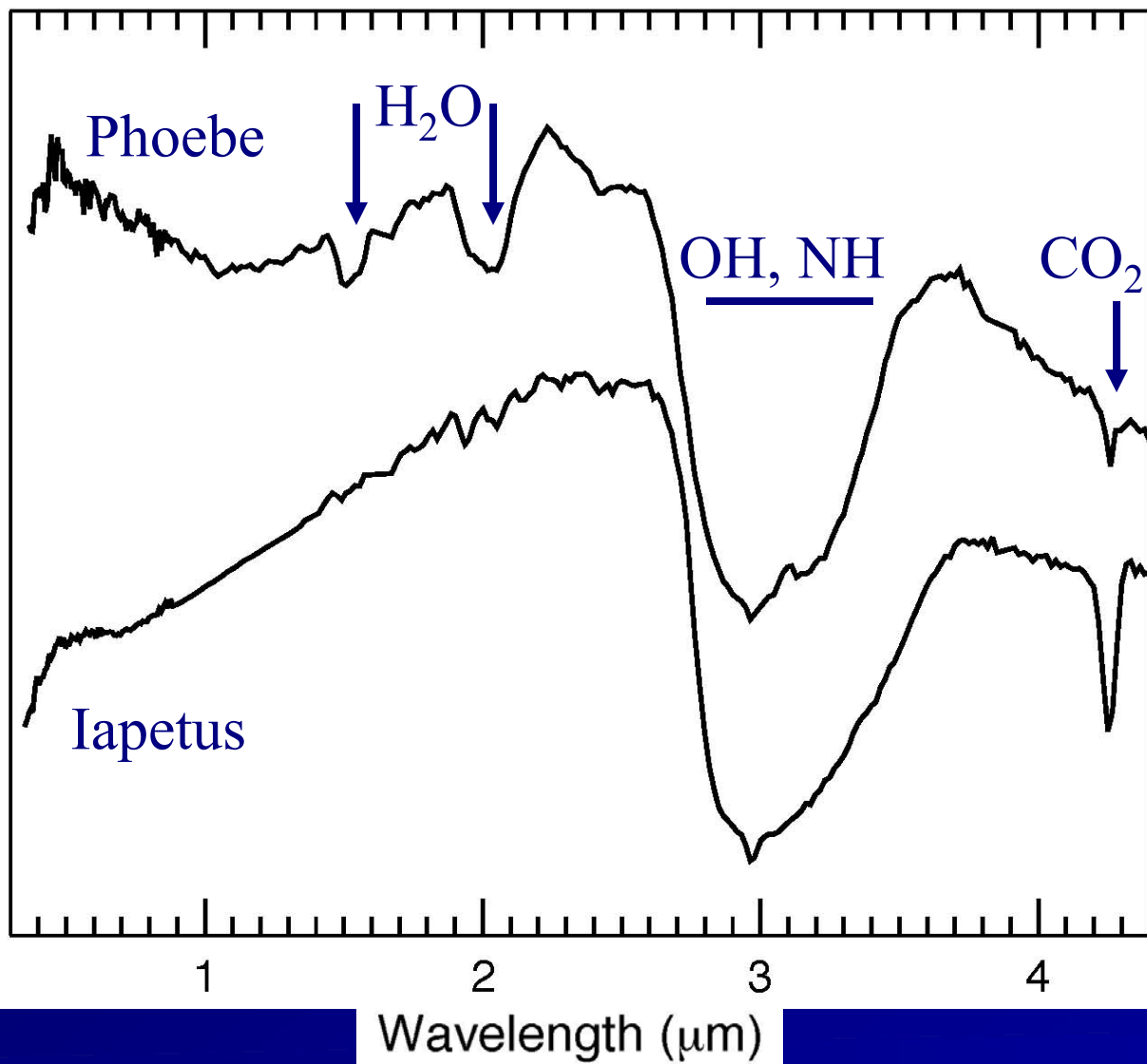
Green = 2.42 μm band

Yellow = CO₂ + 2.42 μm

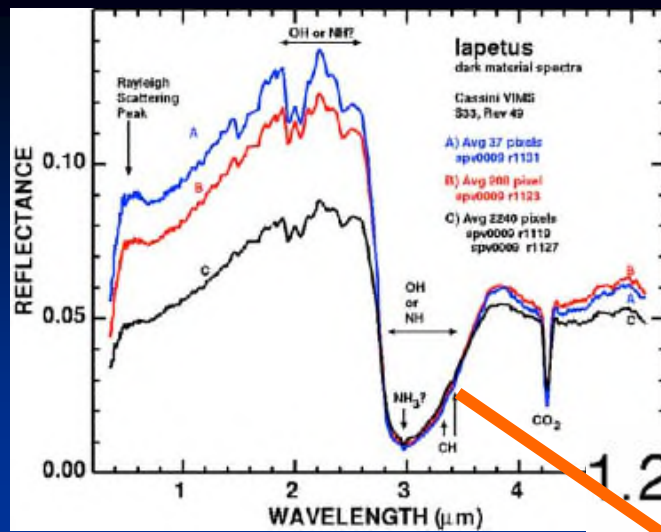
Magenta = H₂O + CO₂

Cruikshank et al. 2007. Nature 448, 54.

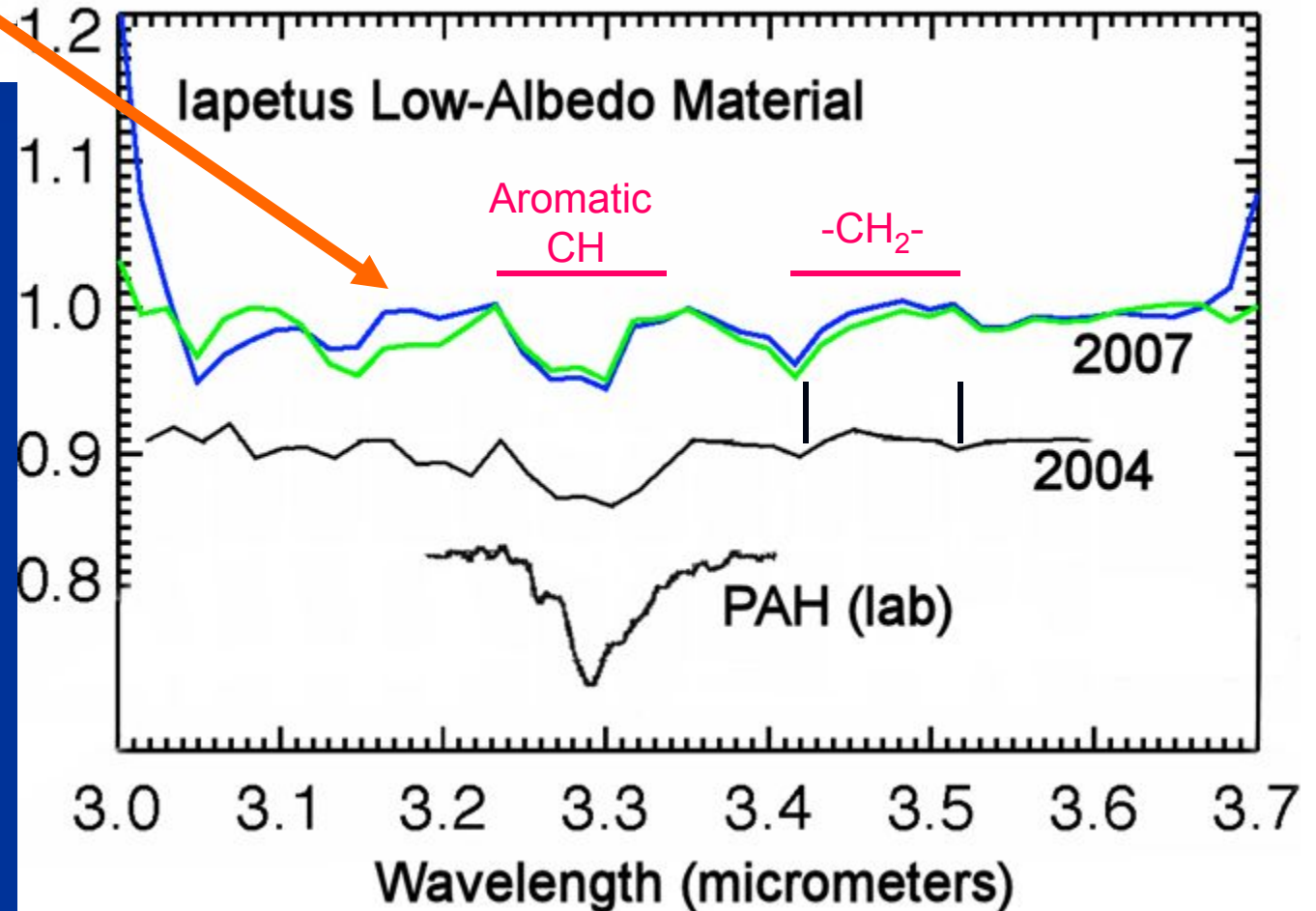
Cassini VIMS spectra of Phoebe and Iapetus

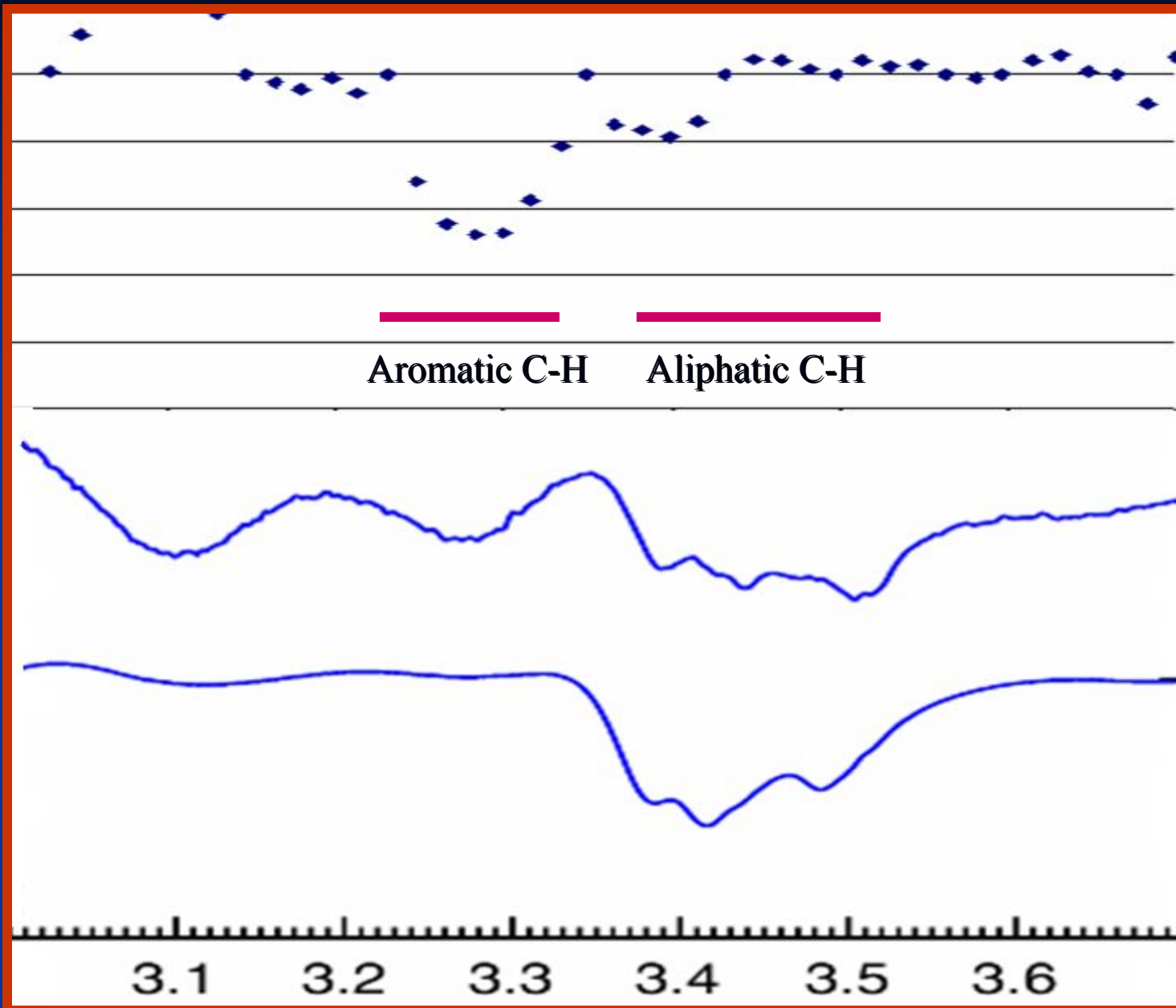


VIMS Spectral Study of Iapetus



Organic solids
on Iapetus.
Cruikshank et al.
Icarus 2008



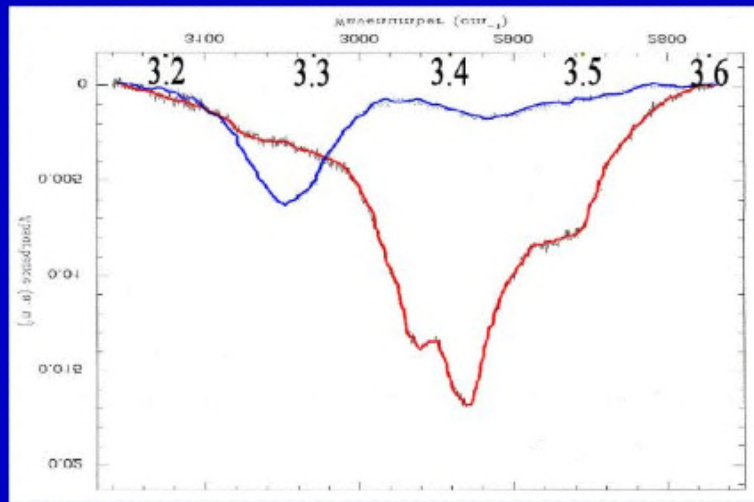


Iapetus
Low-Albedo
Material

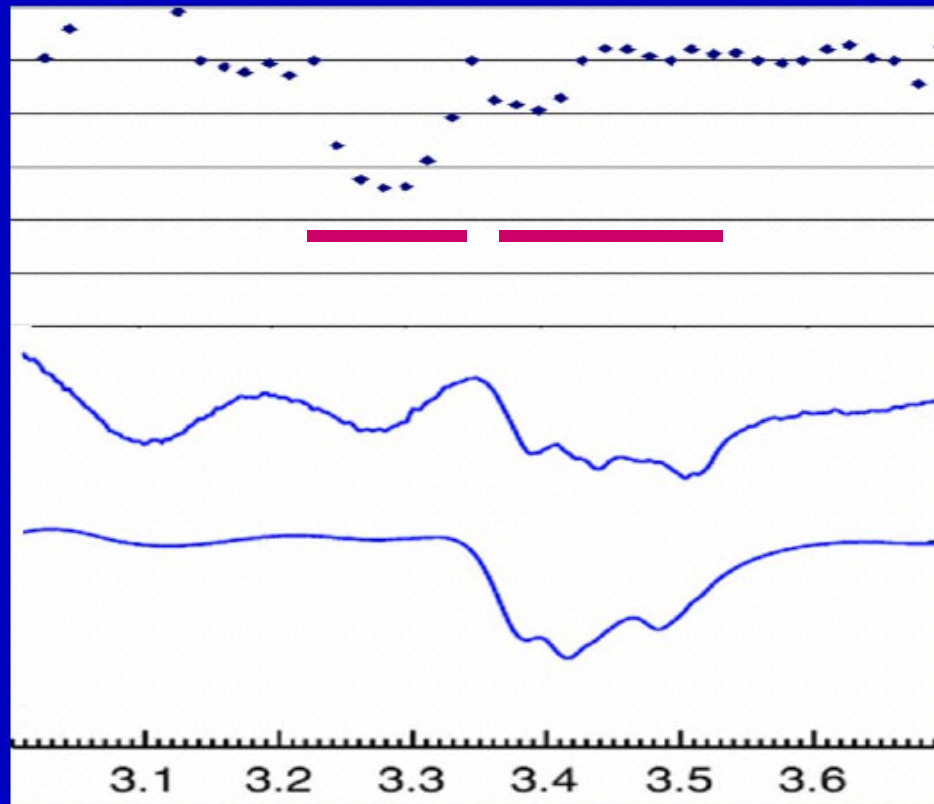
Tagish Lake
IOM

Murchison
IOM

Meteorite
transmission
data from
C. Alexander
& G. Cody



Hydrogenated Amorphous
Carbon (Mennella et al.)



Iapetus
Low-Albedo
Material

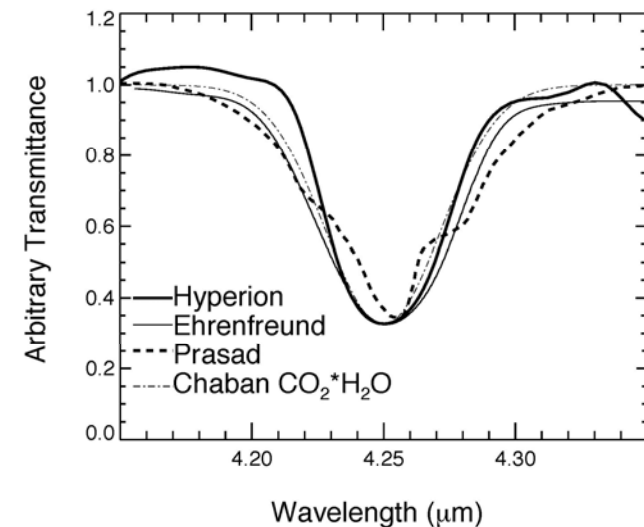
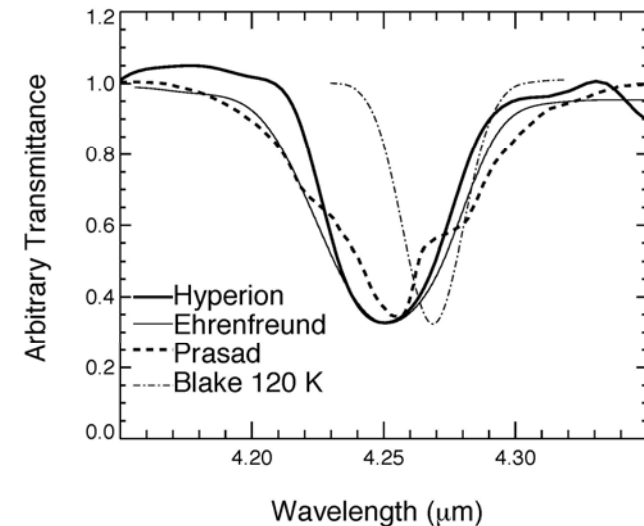
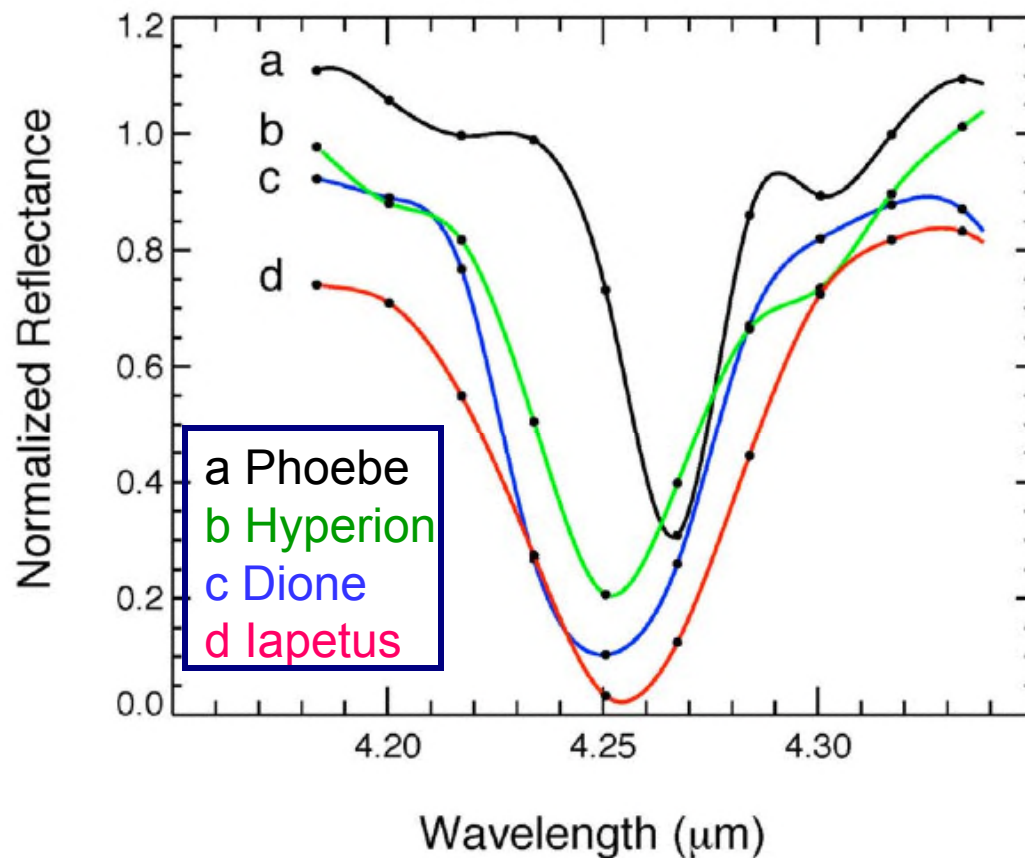
Tagish Lake
IOM

Murchison
IOM

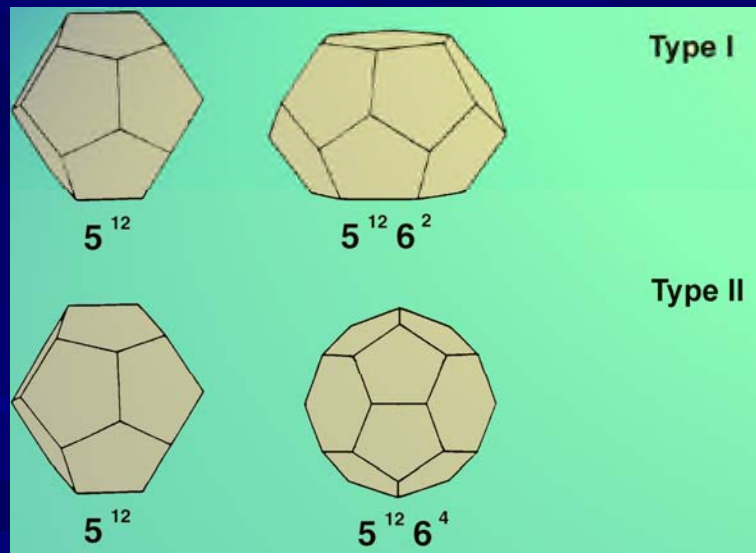
Wavelength μm

Varieties of CO₂ on Saturn's Satellites— Variations in ν_3

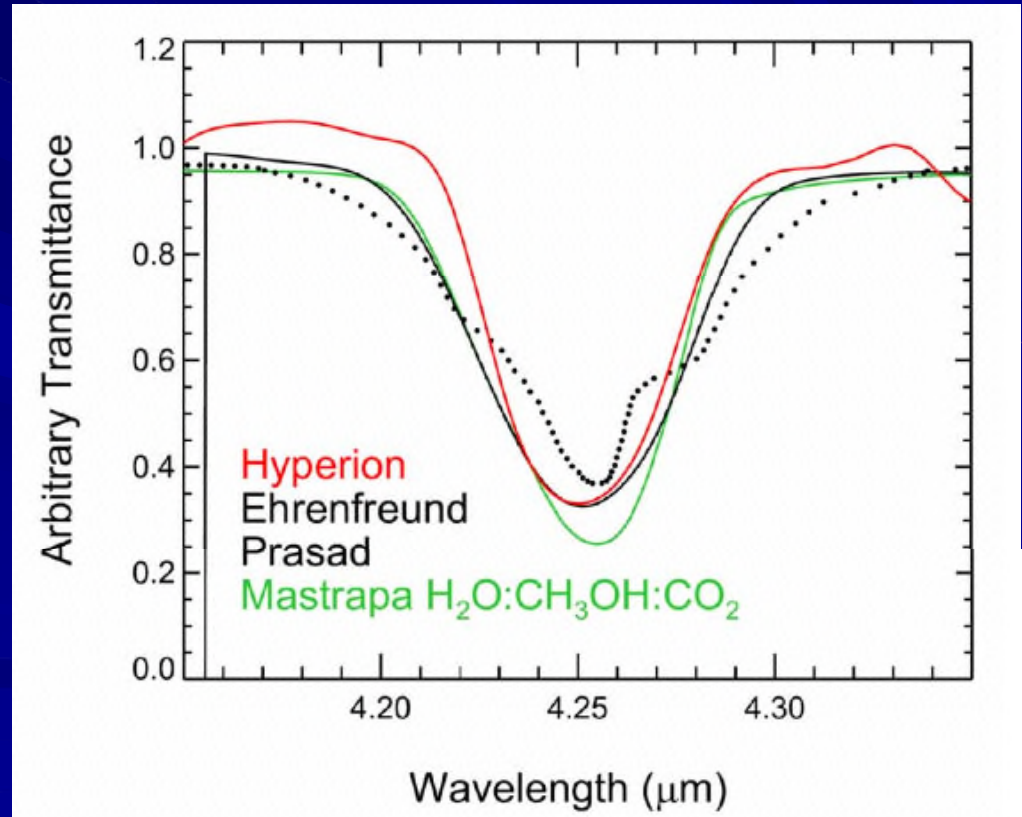
Compared to pure CO₂ ice at $\lambda = 4.628 \mu\text{m}$, CO₂ is shifted to shorter wavelengths and the band is broadened. Phoebe's CO₂ is not shifted.



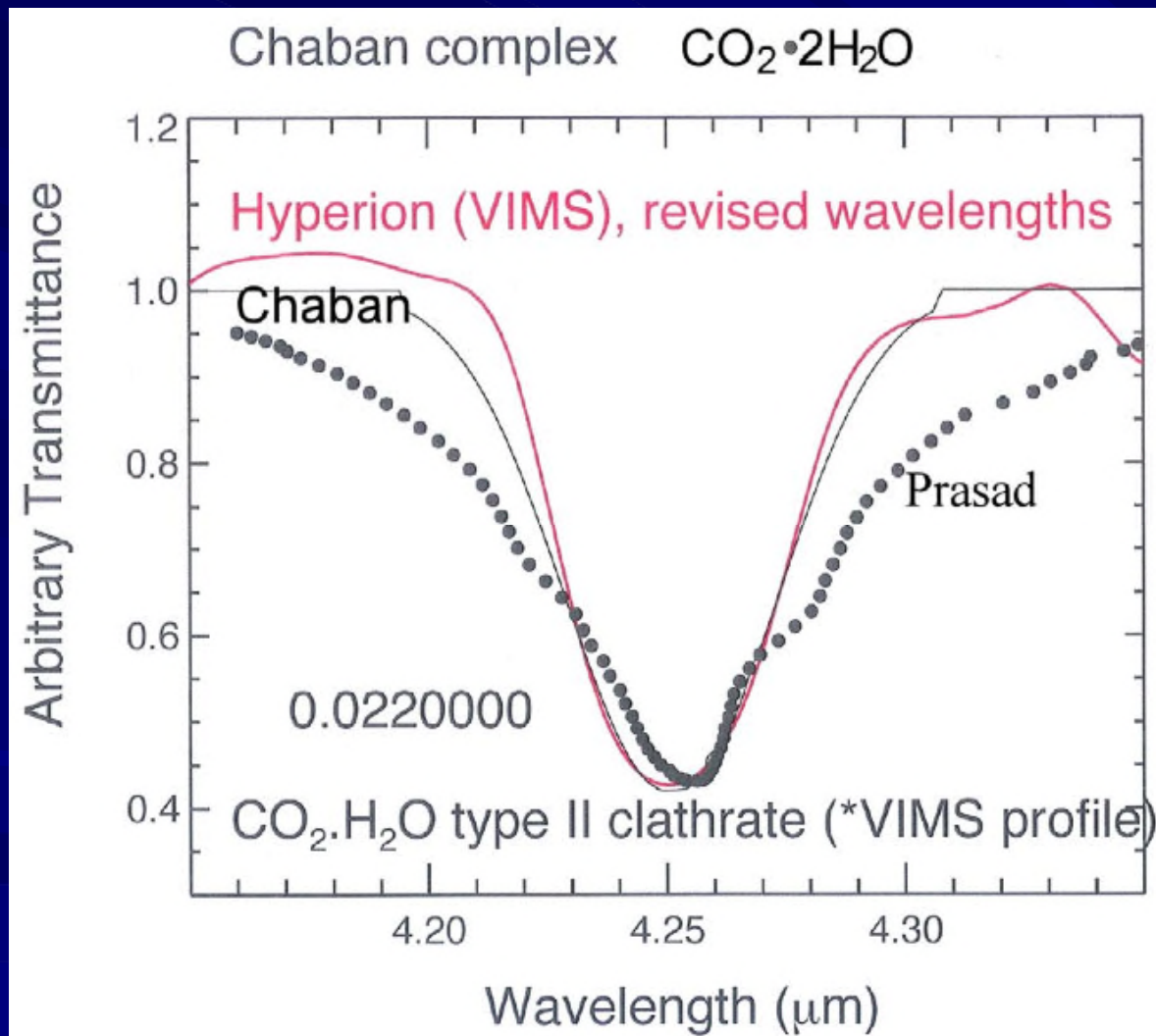
Hyperion conclusion: Wavelength and band shape matched with Prasad clathrate, Ehrenfreund & Mastrapa/Sandford 1:1:1 mixtures, and Chaban et al. $\text{CO}_2 \cdot 2\text{H}_2\text{O}$ calculations.
 \Rightarrow CO_2 is complexed with H_2O and/or other molecules



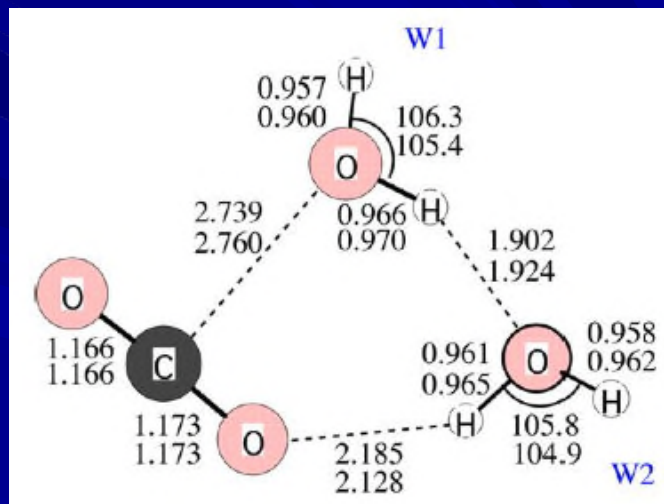
Lab spectra needed for clathrates with verified structure



Chaban theoretical spectrum



The *ab initio* calculation of one CO_2 with two H_2O molecules (plotted as a Gaussian with the VIMS resolution element) fits the Hyperion data well.



Calculations with two levels of molecular theory.
Chaban et al. 2007, Icarus

Laboratory Work

- Optical constants in extended wavelength regions
 - Ices in different phases, organic solids (synthetic and natural)
- Ice mixtures--spectroscopy
 - Matrix isolated hydrocarbons and nitriles
 - Clathrates and other complexes
 - Other mixtures
- Organic solids
 - Analysis and optical constants for complex macromolecular carbonaceous materials (synthetic tholins, meteoritic organic materials (soluble and insoluble))
- Nanoscale metal particles
 - Optical and scattering properties
- Special circumstances
 - Irradiated materials and mixtures
 - Irradiated ice and organic solids mixtures
 - Surface reactions on ice grains

The End